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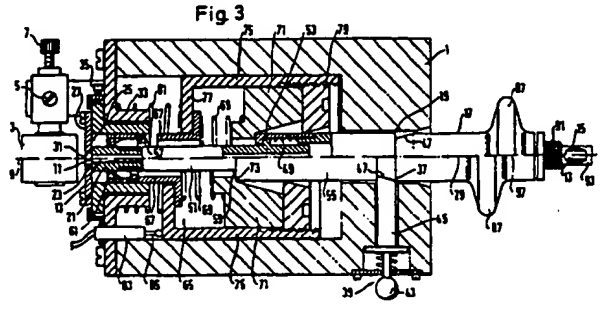
(54) Optical fiber coupling device for a laser head

(57) The rapid and convenient connection of an optical fiber to the coupling site of a laser head is achieved by means of a plug-type connector. The plug-type connector consists of a connector that receives the optical fiber and a tip jack on the laser head. At its free end, the connector has a precisely dimensioned adapter in which the lead section of the optical fiber occupies a fixed position. The correct coupling position of the connector in relation to the coupling site of the laser head is ensured by means of a clamping device that is protected in the laser head and that need be adjusted only once. A safety switch linked to the clamping device prevents the laser from being switched on before the complete coupling of connector and laser head.

Fig. 3



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TRANSLATION *by Corporate Translations, Inc., Mansfield Ctr., CT USA*

Optical fiber c upling device for a laser head

The invention concerns a coupling device for connection of an optical fiber to a coupling site of a laser head.

Normally, the coupling site has very small dimensions such that the coupling of a correspondingly thin optical fiber requires a high degree of positional accuracy. If, for example, the coupling site is a linear focus that is typically 170 µm in diameter as defined by a lens system and the core of the optical fiber has a diameter of 200 µm, the positioning should have a precision of ± 15 µm in order to fully couple the flow of laser energy in the optical fiber. Greater degrees of positional inaccuracy can result in damage or destruction of the optical fiber holder.

Due to the high degree of positional accuracy that is required, in prior art the lead end of the optical fiber is fixed in place in the laser head and adjusted upon installation. Detaching the optical fiber and reinstalling it is then an awkward and time-consuming process, especially because of the new adjustment that is required each time.

The goal of the invention is to design a coupling device of the type mentioned above that permits a quicker and more convenient detachment and recoupling of the optical fiber.

This goal is achieved by the invention with a coupling device of the type mentioned at the outset which is characterized by a plug-type connector that has a connector holding the optical fiber and a predetermined insertion path for the connector, whereby the free end of the connector has a precisely dimensioned adapter in which a lead section of the optical fiber is fixed in position relative to the adapter, whereby adequate clearance is provided between the adapter and the insertion path to permit precise positioning of the adapter relative to the coupling site, and finally whereby the laser head has a clamping device which is actuated by inserting the connector and which locks the adapter in the correct coupling position when the connector is fully inserted.

With the inventive coupling device, the correct coupling position of the connector is ensured solely by the clamping device, which is situated within the laser head and is thus protected, and which is adjusted only once, so that the connector, the insertion path and an efficiently designed locking device that holds the connector in the fully inserted position may exhibit tolerances and can be designed as simple and inexpensive components.

A preferable feature to incorporate is a safety switch that is linked to the actuation of the clamping device and that prevents the laser from being switched on unless the connector is completely inserted and fixed in the correct coupling position.

The invention, as well as forms of the invention and their advantages, are described in more detail below by way of embodiments in conjunction with the drawings.

Figure 1 is a schematic axial sectional view through a connector of an inventive coupling device.

Figure 2 is a schematic, partially sectioned top view of an inventive coupling device with inserted connector.

Figure 3 is a partially sectioned diagram that roughly corresponds to Figure 2 and illustrates the insertion process, whereby the section of Figure 3 above line 57 shows the connector fully inserted, but not yet in its final position, while the section below line 57 shows the connector in its final position.

The same reference numbers are employed in the figures for parts with equivalent functions, irrespective of structural differences.

In a laser head 1, a linear focus is defined by a lens system that can be adjusted with adjustment screws 5, 7 in two coordinate directions perpendicular to an optical axis 9, whereby the linear focus represents a coupling site 11 for a lead section of the core (Figure 1) of an optical fiber 15. The thickness of the core of the optical fiber is greatly exaggerated in the figures for the sake of clarity. A plug-type connector with a connector 17 and an insertion path 19 predetermined in the laser head 1 for the connector 17 serves to couple the optical fiber 15. The free end of the connector 17 has a precisely dimensioned adapter 21 in which the lead section of the optical fiber is fixed in position relative to the adapter 21. In the embodiment illustrated here, the lead section is found in the open face of the cylindrical adapter 21, so that the pivot position of the connector around the axis 9 is irrelevant. The face is ground and polished to optical standards.

Surrounding the lead section, the adapter 21 (Figures 1 and 3) has an annular stopping face 23

which, when the connector is fully inserted, lies flat against an optically ground opposite surface 25 (Figure 3) of a counterpart 27 situated in the laser head 1 and thereby determines the position of the lead section in the direction of insertion 29. The counterpart 27 is a relatively thin plate with a beam transmission hole 31 (Figure 3) that is somewhat larger than the cross-section of the core 13 of the optical fiber 15 to prevent interference with the path of the beam. A clamping device 33 that is connected to the counterpart 27 and can be adjusted on the laser head 1 at right angles to the optical axis 9 in two coordinate axes perpendicular to the optical axis 9 by means of adjustment devices 35 is provided to position the adapter 21 at right angles to the direction of insertion 29.

In order to hold the connector 17 in the fully inserted position, a locking device 37 is provided on the connector 17 and on the laser head. A separately actuated unlocking device 39 is provided to prevent unintentional detachment of the connector. In the embodiment of Figure 2, the unlocking device 39 has a sliding sleeve 41, whereas in the embodiment in Figure 3 it has a hand knob 43 by means of which a spring-loaded locking bar 45 can be withdrawn from a circumferential locking channel 47 of the connector 17.

The clearance necessary to adjust the adapter 21 can be provided in various ways. In the illustrated embodiments, the adapter 21 forms a part of the connector 17 that can be moved to the degree necessary to provide the requisite clearance. This is very simple to do in structural terms. It is expedient to support the adapter 21 opposite to the direction of insertion 29 against a spring 49 (Figures 1 and 3) relative to the other parts of the connector 17. To this end, in the illustrated embodiments the adapter 21 is mounted on a retaining lug 51 that is held in a sleeve-shaped end piece of a main part of the connector 55 by means of a limit stop 53 (Figures 1 and 3). The spring 49 lies between the limit stop 53 and a face of the main part of the connector 55 (Figures 1 and 3) and is prestressed. Sufficient clearance is provided between the retaining lug 51 and the main part of the connector 55 to ensure adequate clearance of the adapter 21 perpendicular to the direction of insertion 29 as well. It is possible to actuate the clamping device 33 through a movement of the connector 17 over the limit stop of the adapter 21 and beyond the counterpart 27 in the direction of insertion 29 by virtue of the possible relative movement in the direction of insertion 29 between the adapter 21 and the other parts of the connector 17.

Accordingly, in the illustrated embodiments the clamping device 33 has a control surface 57 that can be actuated by a spring in the direction of insertion 29, and the connector 17 has control stopping face 59 that works together with it, whereby both surfaces 57, 59 are designed as tori for rotational symmetry about the axis (9).

In the illustrated embodiments, the clamping device 33 takes the form of a known collet chuck and has (Figure 3) a fixed angular or rounded jaw 61 and a jaw 63 that can be moved perpendicular to the direction of insertion 29 and is pressed against the fixed jaw 61 when the control surface 57 is moved in the direction of insertion 29. Otherwise, the mechanical features of the clamping device 33 are not illustrated.

Since the path of movement of the control surface 57 of the clamping device 33 is necessarily very small given the dimensions that are most suitable for laser couplings, it is advantageous, as illustrated, to position a spring buffer 65 between the control surface 57 and the control stopping face 59 of the connector 17 – most effectively situated in the laser head 1 – so that the connector 17 can retain the simplest possible structure. In the illustrated embodiments, the spring buffer 65 consists of an actuating sleeve 67 that surrounds the insertion path of the connector 17 and slides in the direction of insertion 29 so as to act upon the control surface 57 and an intermediate sleeve 71 that is linked to the actuating sleeve 67 in the direction of insertion 29 by means of a prestressed spring 69, whereby the intermediate sleeve 71 exhibits an opposite surface 73 that works with the control stopping face 59 of the connector 17 in the direction of insertion 29. A prestressed sleeve 75 that encloses the actuating sleeve 67 and the intermediate sleeve 71 serves to prestress the spring 69, is mounted in the laser head 1 and exhibits an annular base 77 at its front end and an annular screw plug 79 at its rear end. The prestressing of the spring 69 is useful to permit transmission of the requisite actuating force via the spring 69 with a short actuation path.

As illustrated, the spring buffer 65 is acted upon by a spring 81 opposite to the direction of insertion 29 to prevent premature actuation of the clamping device 33. The spring force of this spring 81 is lesser than that of the spring buffer (of the prestressed spring 69) so that the desired functioning of the spring buffer is not hindered. In the illustrated embodiments, the spring 81 is situated between the prestressed sleeve 75 and the laser head 1. If the actuating sleeve 67 is not firmly connected to the prestressed sleeve 75, as shown, the spring 81

also acts to keep the prestressed sleeve 75 in position against the actuating sleeve 67 even when the prestressed spring 69 is compressed in the last part of the insertion process to achieve the desired buffer effect (in order to ensure complete actuation of the clamping device 33, there must be an extra long insertion path; this is taken up by the spring buffer). Since the prestressed sleeve 75 is thereby held against the actuating sleeve 67, a safety switch 83 for actuation by the prestressed sleeve 75 can be provided; this is easy to do in structural terms. The safety switch 83 only permits operation of the laser when it is actuated (Figure 2 and the lower half of Figure 3) – that is, when the connector 17 is fully inserted and the adapter 21 is correctly positioned. An adjustable switch actuating element 85 can be effectively deployed to adjust the switching point of the safety switch 83; in the embodiment of Figure 2, this takes the form of a disk screwed onto the prestressed sleeve 75, while in the embodiment of Figure 3 it is a more or less screwable switch cover.

The device described above is distinguished in particular by the very simple structure of the connector 17. In the illustrated embodiments, the connector 17 is pipe-shaped and has a convenient grip end 87. The optical fiber 15 is simply guided lengthwise through the connector and fixed in place in the connector. Due to the movement of the adapter 21 relative to the other parts of the connector 17, it is expedient to mount a strain-relief device 89 on the adapter 21; another strain-relief device 91 is provided at the rear end of the connector. As indicated, in the simplest case the strain-relief devices 89, 91 are designed as crimps that grip the plastic cable housing 93 of the optical fiber 15.

The mode of operation of the illustrated device is evident from the above description and the figures, and is explained below with reference to Figure 3. Upon insertion of the connector 17, the state illustrated in the upper half of Figure 3 is reached first, in which the stopping face 23 at the front end of the adapter 21 lies against the opposite surface 25. When the main part of the connector 55 is then moved further in the direction of insertion 29, the actuating sleeve 67 is pressed against the control surface 57 of the clamping device 33 by means of the prestressed spring 69. The clamping device 33 thereby clamps the adapter 21 perpendicular to the direction of insertion in the correct coupling position. When the insertion process in continued until the locking device 37 engages, the spring 69 is compressed. The engaged final state is illustrated in the lower half of Figure 3. During the insertion movement, the safety switch 83 is actuated when the clamping device 33 is closed.

Claims

1. Laser coupling device to connect an optical fiber (15) to a coupling site (11) of a laser head (1), whereby the coupling device takes the form of a plug-type connector that has a connector (17) holding the optical fiber (15) and a predetermined insertion path (19) for the connector (17) in the laser head (1), the free end of the connector (17) has a precisely dimensioned adapter (21) in which a lead section of the optical fiber (15) is situated in a fixed position relative to the adapter (21), adequate clearance is provided between the adapter (21) and th insertion path to permit precise positioning of the adapter (21) relative to the coupling site (11), and the laser head (1) exhibits a clamping device (33) that is actuated by inserting the connector (17) and that locks the adapter (21) in the correct coupling position when the connector (17) is fully inserted.

2. Device according to claim 1, whereby the lead section is situated in the open face of the adapter (21), the adapter (21) exhibits an annular stopping face (23) that surrounds the lead section, whereby with fully inserted connector (17) the stopping face (23) determines the position of the lead section in the direction of insertion (29), and the clamping device (33) for fixing the position of the adapter (21) is situated at right angles to the direction of insertion (29).

3. Device according to claim 1 or 2, whereby a locking device (37) that holds the connector (17) in its fully inserted position is provided on the laser head (1) and the connector (17).

4. Device according to claim 3, whereby the locking device (37) has a separately operable unlocking device (39).

5. Device according to one of the preceding claims, whereby the adapter (21) is supported by the other parts of the connector (17) in such as a way as to be movable to the extent necessary to ensure an adequate degree of clearance.

6. Device according to one of the preceding claims, whereby the adapter (21) is movable relative to the other parts of the connector in a direction opposite to the direction of insertion (29) against the spring (49).

7. Device according to claim 6, whereby the clamping device (33) has a control surface (57) that can be actuated in the direction of insertion (29), and the other parts of the connector (17) exhibit a control stopping face (59) that works together with it.

8. Device according to claim 7, whereby a spring buffer (65) is provided between the control surface (57) and the control stopping face (59).

9. Device according to claim 8, whereby the spring buffer (65) is situated in the laser head (1) and exhibits an actuating sleeve (67) that slides in the direction of insertion (29) and surrounds the insertion path (19) of the connector (17) for acting upon the control surface (57), and also exhibits an intermediate sleeve (71) that is linked to the actuating sleeve (67) in the direction of insertion (29) by means of a prestressed spring (69) and works with the control stopping face (59), and the actuating sleeve (67) and the intermediate sleeve (71) are supported by a prestressed sleeve (75) that slides in the direction of insertion (29) against the prestressed spring (69).

10. Device according to claim 9, whereby the prestressed sleeve (75) is acted upon opposite to the direction of insertion (29) by a spring (81) whose force is lesser than that of the spring buffer (65).

11. Device according to one of the preceding claims, characterized by a safety switch (83) that is linked to the actuation of the clamping device (33).

12. Device according to claims 10 and 11, whereby the safety switch (83) can be actuated depending on the position of the prestressed sleeve (75).

13. Device according to claim 12, whereby an adjustable switch actuating element (85) is provided to adjust the switching point of the safety switch (83).

14. Device according to one of the preceding claims, whereby the clamping device (33) is adjustable in two coordinate directions at right angles to the optical axis (9).

15. Optical fiber connector for insertion in a laser head, characterized by the features of the connector described in one of the preceding claims.

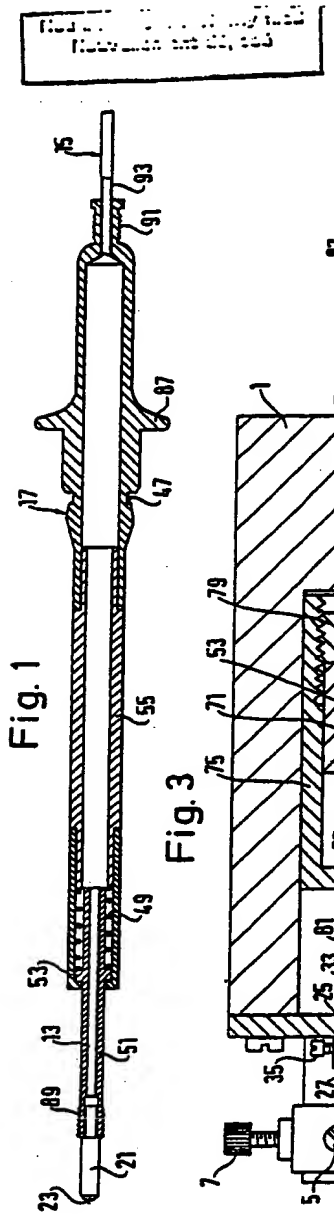


Fig. 1

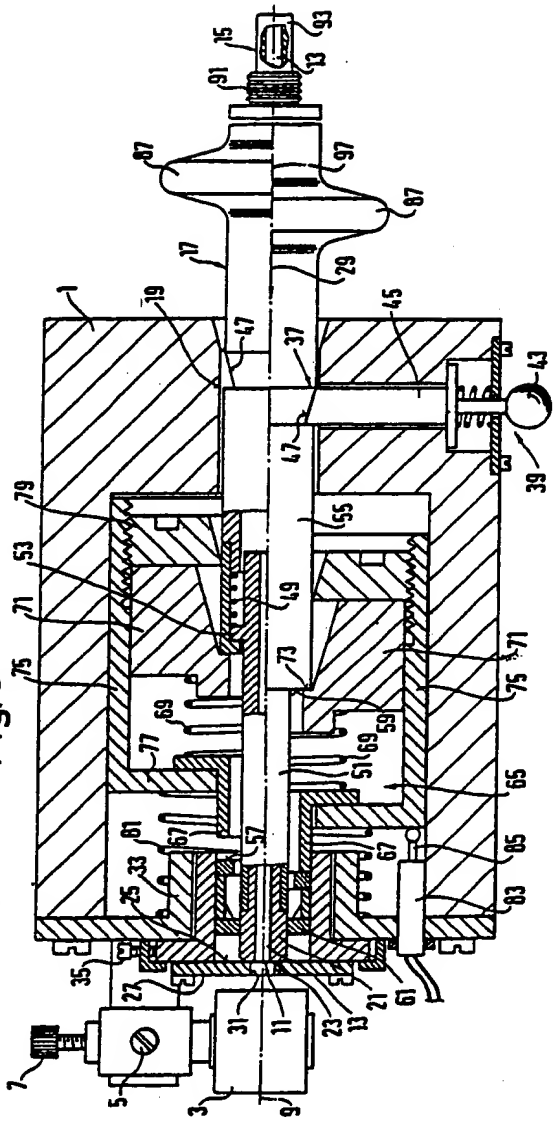
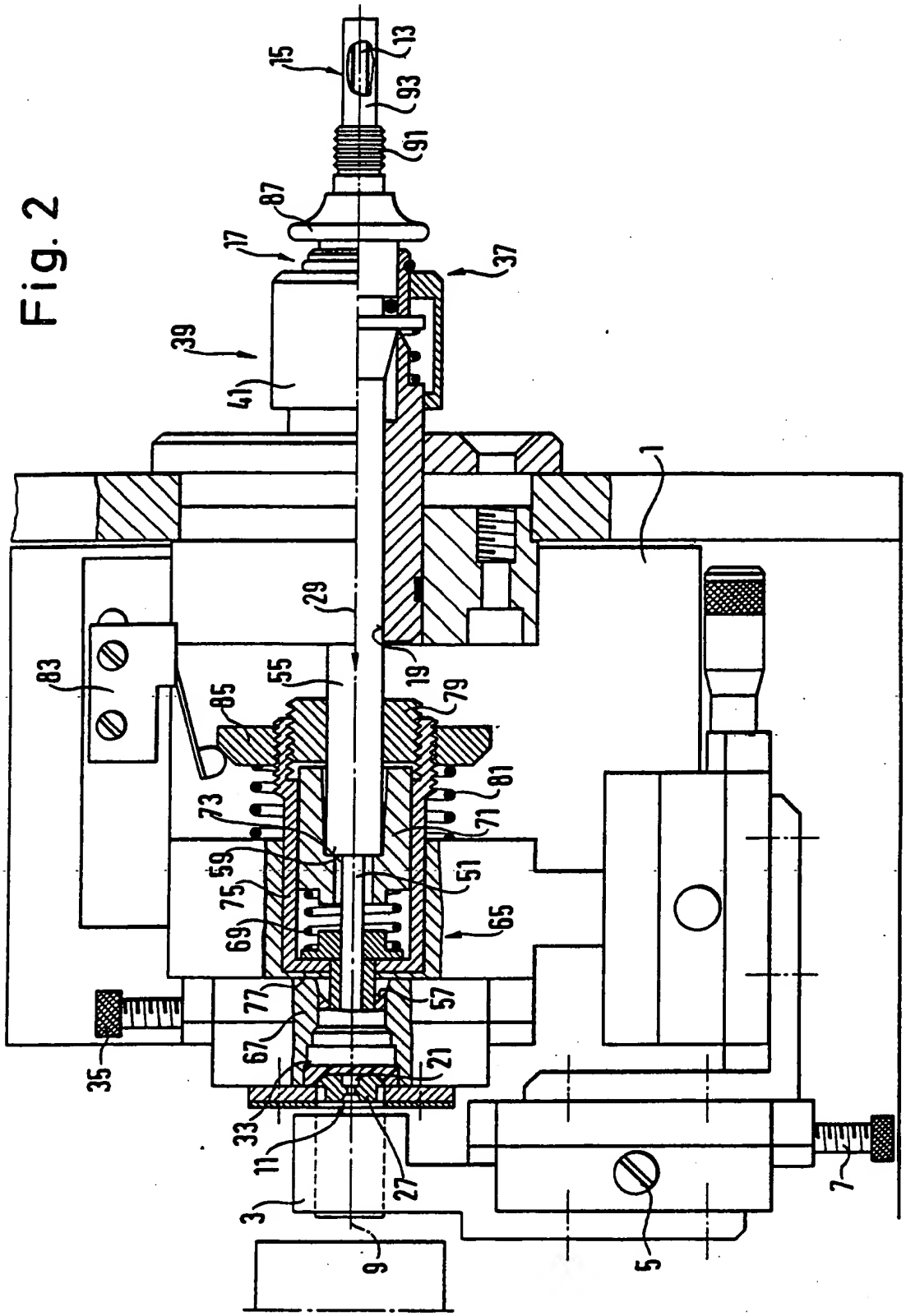


Fig. 3

Fig. 2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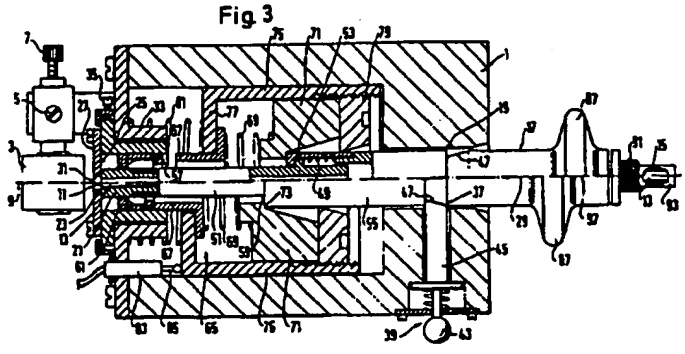
(54) Optical fiber coupling device for a laser head

(57) The rapid and convenient connection of an optical fiber to the coupling site of a laser head (1) is achieved by means of a plug-type connector. The plug-type connector consists of a connector (17) that receives the optical fiber (15) and a tip jack on the laser head. At its free end, the connector has a precisely dimensioned adapter (21) in which the lead section of the optical fiber occupies a fixed position. The correct coupling position of the connector in relation to the coupling site (11) of the laser head is ensured by means of a clamping device (33) that is protected in the laser head and that need be adjusted only once. A safety switch (83) linked to the clamping device prevents the operation of the laser before the complete coupling of connector and laser head.

Fig. 3



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